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(54) **Device for validating banknotes.**

(57) The device (10) comprises a pair of superimposed plates (14-15) which define a compartment (13) for receiving the banknotes, banknote grip and traction elements (16-17), rows of light-emitting diodes (26 to 29) for illuminating the banknote in succession and with radiation having different wavelengths, and a solid-state sensor (CCD) (30) which receives the linear images which are the result of the selective illumination produced by each row of diodes. The digitized data related to the acquired linear images are compared with corresponding data of authentic and counterfeit specimens and, depending on the result of the comparison, the tested banknote is accepted or rejected.

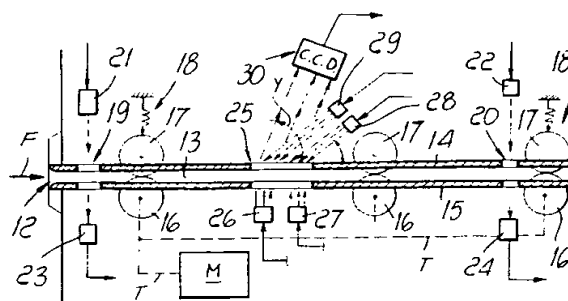


FIG. 2

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The present invention relates to a device for validating banknotes and more precisely to a device able to provide a response, in terms of acceptance or rejection, regarding the validity of banknotes checked by the device.

Typically, the validation device according to the invention is intended to be included in prepayment machines and, particularly, in machines for dispensing cards for enabling public telephones, fuel pumps, highway toll gates and the like.

Banknote validation devices provided with optical sensors are already known wherein the criterion of acceptance or rejection is based on the response of optical sensors which are sensitive to variations in light rays reflected and/or refracted by the banknote being tested.

The reliability of the above known devices, however, is not satisfactory, since the response of the optical sensors depends on many variables and because it is very difficult to provide sampling thresholds which are sufficiently selective and stable, especially with regard to temperature.

Due to this reason, the above mentioned known validation devices have proved themselves unsuitable to recognize particularly well-imitated counterfeits which, with current printing methods, are increasingly easier to obtain.

The aim of the present invention is to eliminate these problems and, within the scope of this general aim, it has the following important particular objects:

- to provide a generic-banknote validation device which is highly reliable and is capable, in particular, of recognizing and rejecting particularly well-imitated counterfeits;
- to provide a generic-banknote validation device which does not require particular positioning of the banknote being tested, so that said banknote can be recognized independently of the insertion direction and of the exposed face;
- to provide a validation device which is also improved mechanically, in particular one that is structurally simple and reliable also in terms of avoiding the jamming of the banknotes inserted therein.

In order to achieve this aim, these important objects and others which will become apparent from the following detailed description, the present invention relates to a device for validating banknotes which is characterized in that it comprises:

- a pair of superimposed plates which define a compartment for receiving the banknotes to be inspected;
- banknote grip and traction elements and light-sensing banknote positioning means associated with said receiving compartment;
- rows of solid-state means for the refracted and reflected illumination, with different

wavelengths, of the banknote which is present in the receiving compartment, and solid-state means for receiving the linear images which are the result of the selective illumination produced by each row of illumination means;

-- means for storing the digitized data which correspond to the acquired linear images and logic means for comparing the data of the acquired images with the data, present in system memories, which correspond to specimen images related to authentic and/or typical counterfeit banknotes and for producing acceptance or rejection signals depending on the result of the comparison.

The invention will become apparent from the following detailed description and with reference to the accompanying drawings, illustrated only by way of non-limitative example and wherein:

figure 1 is a perspective view of the device;

figure 2 is a schematic sectional view, taken along the plane II-II of figure 1;

figure 3 is a block diagram of the circuitual arrangement of the device.

The device according to the invention is formed by a parallelepipedal cabinet 10 on whose front face an inlet 11 is arranged; said inlet defines a slot 12 for inserting the banknotes B. The slot 12 is aligned with the banknote receiving compartment 13, which is delimited by a pair of superimposed plates 14 and 15 preferably made of polymeric material which extend inside the cabinet 10.

A set of three driving rollers 16 for banknote traction is spread throughout the receiving compartment 13; a corresponding set of three presser rollers 17 cooperates with said driving rollers, and said presser rollers are mounted so that they can rotate freely on the respective supporting pins and are subjected to the action of elastic means 18 which push them into elastic contact with the respective driving rollers.

The driving rollers 16 are operated by a bidirectional electric motor M by means of an adapted transmission T, advantageously a belt transmission. First and second openings 19 and 20 are defined in the pair of plates 14 and 15, and corresponding infrared-light emitting diodes or LEDs 21-22 are aligned therewith and cooperate with respective infrared-light sensors 23-24 in order to detect the insertion and positioning of each banknote.

A third opening 25 is provided on both plates substantially in their median region. A row of red light-emitting LEDs 26 and a row of infrared-light emitting LEDs 27 are arranged on the lower side of the plates (with reference to figure 2) and aligned with the opening 25; both rows are intended to illuminate the banknote for transparency, and are arranged side by side and transversely to the bank-

knote insertion direction, which is indicated by the arrow F in figure 2.

A row of red-light emitting LEDs 28 and a row of green light-emitting LEDs 29, intended to illuminate the banknote for reflection, are arranged on the upper side of the plates and adjacent to said opening 25.

As clearly shown in the figure, the LEDs 26 and 27 are positioned at right angles to the surface plane of the banknote, and the LEDs 28 and 29 form an angle of incidence "i" which is different from 90°. A solid-state sensor 30 is arranged above the plates 14 and 15 and is positioned at an angle of incidence "y" which is greater than the angle "i", in order to receive, through an optical lens which is not illustrated, both the rays of the emitters 26 and 27 refracted by the banknote and the rays of the emitters 28 and 29 reflected by said banknote. The sensor 30 is of the linear CCD type, for example with 128 pixels, and advantageously comprises the Toshiba TCD 104 integrated circuit.

With reference now to the diagram of figure 3, it can be seen that the sensor 30 is connected, with the interposition of an A/D converter 31 and of an automatic selector 32, to a block 33 of four memories which are intended to store the data related to respective linear images which are selectively acquired by the sensor 30 and are the result of the selective activation of the rows of diodes 26 to 29.

The output of the memories 33 is connected to a recognition logic unit 34 to which further static system memories 36 or 37 are selectively connected; said memories 36 or 37 respectively contain "banknote-face" data related to reference genuine specimens (authentic banknotes) and banknote-face data related to reference counterfeits (counterfeit banknotes). The term "banknote face" defines the face of said banknote according to a specific view, and therefore each banknote is characterized by four "banknote faces".

The recognition logic unit is bidirectionally connected to a control logic unit 38 which is in turn bidirectionally connected, by means of a serial interface 39 and a parallel interface 40, to the host machine, which is not illustrated. The control logic unit 38 furthermore drives a logic unit 41 for the forward-reverse operation of the motor M, which operates the traction rollers, and a logic unit 42 which controls the selector 32 and, by means of a further selector 43, drives the selective activation of the rows of diodes 26 to 29. In turn, the control logic unit 38 receives the control data of a logic unit 44 which is associated with the infrared-light sensors 23-24 for detecting the position of the banknote.

The operating method of the described device is as follows:

-- the banknote inserted in the slot 12 is detected by the infrared-light sensor 23 which, by means of the control logic unit 38, activates the motor M and the rollers 16 which pull said banknote into the receiving compartment 13. Simultaneously, under the control of the logic units 38 and 42 and by means of the selectors 43 and 32, the rows of diodes 26 to 29 are switched on in a selective sequence, and the data related to the four linear images acquired by the sensor 30 are stored, with the same sequence, in the respective memories of the block 33. At the end of the process, the data of four images of the same banknote face are thus present in the four memories of the block 33. Subsequently, traction of the banknote is halted and the control logic unit 38 activates the recognition logic unit 34, which compares the data of the four acquired images with N sets of four specimen image data related to N genuine banknote faces and with N sets of four image data related to false reference banknote faces. The outcome of the comparison (match/no match) is transmitted to the control logic unit 38 which in turn transmits the information to the two interfaces 39-40 towards the host machine (not illustrated) and actuates the forward traction of the banknote in the direction of the arrow F (acceptance) or in reverse (rejection), as appropriate. The infrared-light sensors 23 or 24 indicate completion of the operation.

According to the invention, the device can furthermore operate in a self-learning mode which can be set manually, for example by means of selectors 50 or by means of commands sent to the serial line.

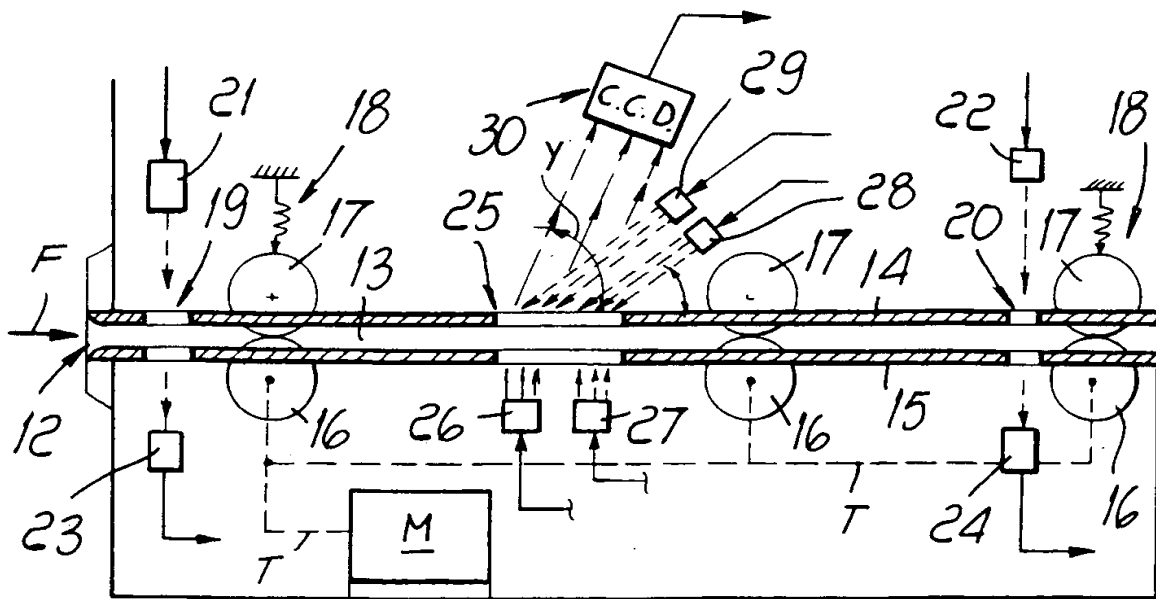
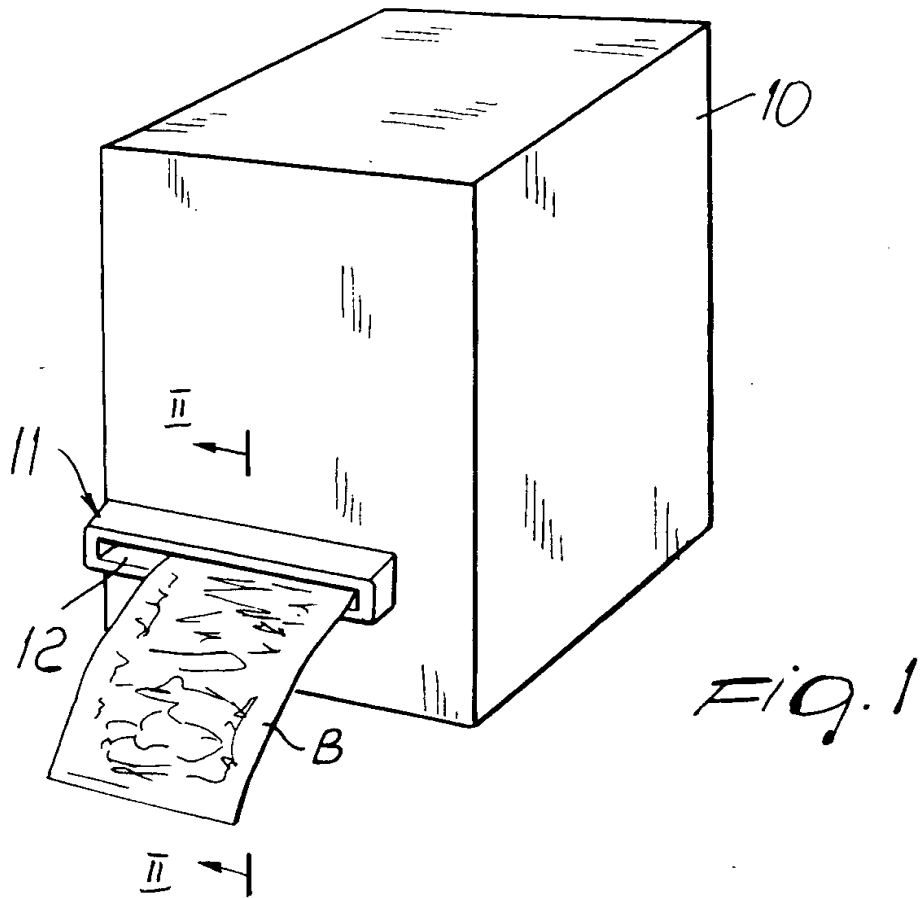
In self-learning mode, the data acquired in the memory block 33 are sent, by means of a switch 51, to the memories 36 or 37, and the inserted banknote face is thus stored, as appropriate, in the reference genuine-specimen memory or in the reference counterfeit memory.

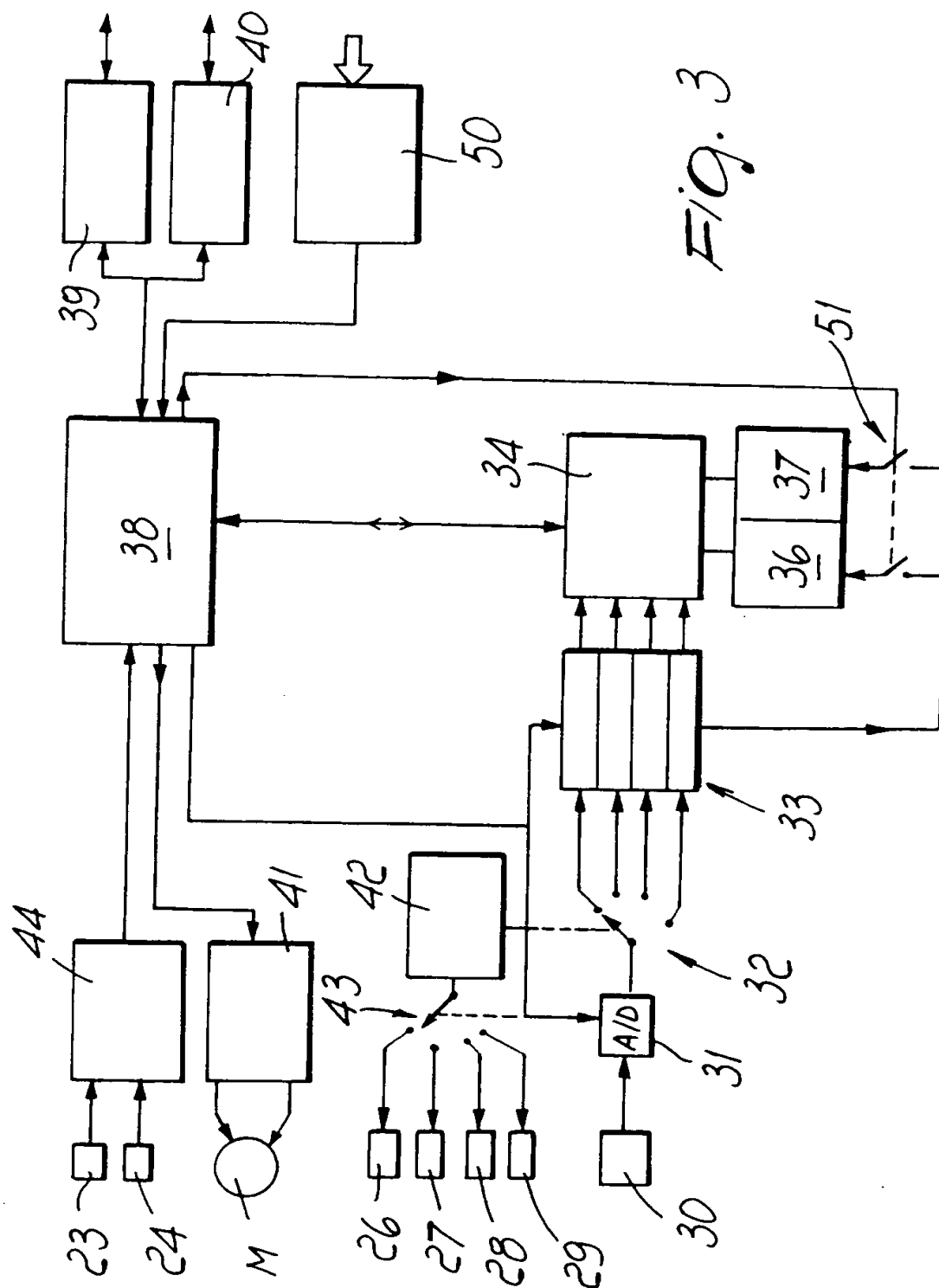
Naturally, without altering the concept of the invention, the details of execution and the embodiments may be varied extensively with respect to what is described and illustrated by way of non-limitative example without thereby abandoning the scope of the invention.

Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

## Claims

1. Device for validating banknotes, characterized in that it comprises:
  - a pair of superimposed plates (14,15) which define a compartment (13) for receiving the banknotes to be inspected, banknote grip and traction elements (16,17), and light-sensing banknote positioning means (21,22,23,24), associated with said receiving compartment;
  - rows of solid-state means for the refracted (26,27) and reflected (28,29) illumination, with different wavelengths, of the banknote which is present in the receiving compartment (13), and solid-state means (30) for receiving the linear images which are the result of the selective illumination produced by each row of illumination means;
  - means for storing the digitized data (33) which correspond to the linear images acquired by the receiving means and logic means (34) for comparing the data of said acquired images with data, present in system memories, of corresponding specimen images related to typical authentic and/or counterfeit banknotes and for producing acceptance or rejection signals depending on the result of the comparison.
2. Device according to claim 1, characterized in that the banknote grip and traction elements are constituted by driving rollers (16) and by presser rollers (17) and in that the driving rollers are moved by a bidirectional electric motor which is controlled by a drive logic unit (41).
3. Device according to claim 1, characterized in that it comprises four rows (26,27,28,29) of light-emitting diodes arranged in pairs on the opposite sides of the pair of plates aligned with an opening (25) located in a substantially median region of said pair of plates.
4. Device according to claims 1 and 3, characterized in that one pair of rows of diodes (26,27) is arranged below said plates and illuminates the banknote for transparency and the other pair of rows of diodes (28,29) is arranged above the plates and illuminates the banknote for reflection.
5. Device according to claims 1 and 4, characterized in that the image receiving means is arranged above the pair of plates and is constituted by a CCD sensor (30).
6. Device according to claims 1, 3 and 4, characterized in that the two rows of diodes (26,27) arranged below the pair of plates emit radiation in the infrared and red ranges and the two rows of diodes (28,29) arranged above the plates emit radiation in the red and green ranges.
7. Device according to claims 1 and 5, characterized in that the solid-state sensor (30) which constitutes the means for receiving the linear images is connected, with the interposition of an A/D converter (31) and of an automatic selector (32), to a block of four memories (33), each memory being intended to store the data of the corresponding linear image formed by the illumination produced by each row of diodes.
8. Device according to claim 7, characterized in that the outputs of said memory block are operatively connected to a recognition logic unit (34) which also receives the specimen data of the genuine banknotes or counterfeits contained in the system memories and in that said recognition logic unit is bidirectionally connected to a control logic unit (38) which receives the banknote position detection data and sends the commands for powering the traction motor, the commands for switching on the rows of diodes in succession and the commands for selecting the image data memories; the control logic unit being operatively connectable to host machines by virtue of serial (39) and parallel (40) interfaces.
9. Device according to claims 1 and 8, characterized in that it comprises self-learning selectors (50) which are associated with the control logic unit (38) and are able to switch the data related to the images acquired by the solid-state sensor onto the system memories intended to contain the reference genuine banknotes or the counterfeits.







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## EUROPEAN SEARCH REPORT

Application Number

EP 92 11 6190

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	US-A-3 679 314 (RUDOLF MUSTERT) 25 July 1972 * the whole document * ---	1-3	G07D7/00
Y	EP-A-0 078 708 (DE LA RUE SYSTEMS) 11 May 1983	1-3	
A	* abstract; claim 1; figures 1,2 * * page 1, line 10 - page 7, line 14 * ---	4-8	
A	GB-A-2 078 368 (DE LA RUE SYSTEMS) 6 January 1982 * the whole document * ---	1-9	
A	EP-A-0 314 312 (DE LA RUE SYSTEMS) 3 May 1989 * abstract; claims; figure 1 * ---	1-5	
A	GB-A-2 088 051 (ROWE INTERNATIONAL) 3 June 1982 * abstract; claim 1 * ---	1-3	
A	WO-A-8 502 928 (BERGSTRÖM) 4 July 1985 * abstract; claims * ---	1	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	EP-A-0 194 331 (MITSUBISHI JUKOGYO K.K.) 17 September 1986 * page 6, line 24 - page 16, line 18 * ---	1	G07D
A	EP-A-0 395 833 (LANDIS & GYR) 7 November 1990 ---		
A	US-A-3 491 243 (TAISUKE TSUGAMI) 20 January 1970 -----		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 15 JANUARY 1993	Examiner GUIVOL O.
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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